



I hereby certify that this correspondence is being deposited with the U.S. Postal Service as Express Mail, Airbill No. EV361364719US, in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date shown below.

Dated: 7-21-04 Signature: Carol Martin
(Carol Martin)

Docket No.: 45688-00002USPT
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Fen-Ren Chien et al.

Application No.: 09/434318

Filed: November 4, 1999

For: FLIP-CHIP LIGHT-EMITTING DEVICE

Allowed: December 5, 2003

Confirmation No.: 3814

Art Unit: 2814

Examiner: T. T. Doan

RENEWED PETITION UNDER 37 CFR 1.47(B)

MS: Petitions
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Applicants hereby submit a renewed petition under 37 CFR 1.47(b) to the Commissioner for reconsideration of the Decision Refusing Status under 37 CFR 1.47(b), mailed April 21, 2004, to accept the filing of the above-identified U.S. Patent Application by other than all of the inventors. A Declaration of Facts of Mr. Wesley Shen, a senior staff member employed by Uni Light, and Mr. Liu Hun-Huang, an employee of Uni Light, are enclosed under separate title. The facts therein establish that diligent efforts have been made by Mr. Shen and Mr. Hun-Huang to contact all of the joint inventors, Fen-Ren Chien, and Schang-Jing Hon. The facts therein also establish that (i) Mr. Chien refused to sign a Declaration and Assignment ("Filing Documents"), and (ii) Mr. Hon cannot be reached to sign the Filing Documents. Accordingly, relief under 37

CFR 1.47(b) is respectfully requested.

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Regarding item (1) of the Decision Refusing Status, it was indicated on page 1, fifth paragraph, that the Applicants have failed to show or provide proof that the nonsigning inventors have refused to sign the declaration after having been presented with a copy of the application papers. The Decision Refusing Status indicated that unless the petitioner can show that a copy of the application papers was presented to each of the nonsigning inventors, then petitioner will have to mail a copy of the complete application to the last known address of the inventors, accompanied by a cover letter of instructions setting a deadline or statement that no response will constitute a refusal.

In response to item (1), Mr. Lin Hun-Huang, employee of Uni Light, mailed a second copy of the application papers and Filing Documents on June 30, 2004, to the last known address of each of the inventors (a first copy was sent to the inventors on March 7, 2000). A cover letter was mailed accompanying the application papers containing instructions to sign and return the Filing Documents by the deadline of July 15, 2004, and that lack of response by that date would indicate a refusal to sign. A copy of the letters, certificates, application papers, and Filing Documents, is attached as Exhibits A-B. No response to the mailing was received from Mr. Chien or Mr. Hon. Mr. Chien verbally declined to sign the declaration in a telephone call with Mr. Wesley Shen of Uni Light on March 3, 2000. Mr. Hon previously signed and returned the Filing Documents for the corresponding Taiwanese patent application under Article 7 of the R.O.C. patent laws (see Appendix E of the petition of June 3, 2000).

In regards to the confusion as to how each of the nonsigning inventors verbally refused to sign at the same time (see, Decision Refusing Status, page 2, first full paragraph), the Declaration of Fact for Mr. Wesley Shen, submitted herewith, indicates that Mr. Shen called Mr. Fen-Ren Chien at 3:05pm on March 3, 2000. During the call, Mr. Shen requested that Mr. Chien sign the documents required for filing the patent application. Mr. Chien verbally declined

to sign the documents. The original letter to Hon was incorrect in stating that Mr. Wesley Shen called him on March 3, 2000 at 3:00 pm.

In regards to the requirement of "diligent effort" in locating Mr. Hon (see, Decision Refusing Status, page 2, last paragraph), Applicants submit that a diligent effort has been made. As previously discussed, a post certified letter including a copy of the application and instructions was mailed to Mr. Hon's last known address. In addition, the Declaration of Fact for Mr. Wesley Shen indicates that Mr. Shen checked with Uni Light employees who worked with Mr. Schang-Jing Hon during employment with Uni Light. None of the co-workers had knowledge of the current contact information for Mr. Hon.

In view of the foregoing discussion, Applicants respectfully request granting of the renewed petition under 37 CFR 1.47(b).

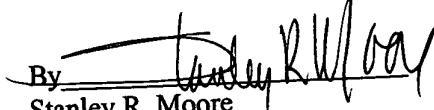
Application No.: 09/434318
Customer No. 23932

Docket No.: 45688-00002USPT

Enclosed is a check that includes the fee set forth in 37 CFR 1.17(h). Please debit any underpayment or credit any overpayment to Deposit Account No. 10-0447.

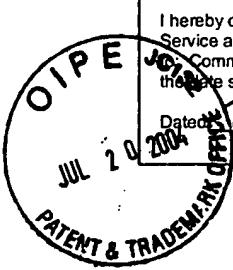
Dated: July 21, 2004

Respectfully submitted,

By 

Stanley R. Moore

Registration No.: 26,958
JENKENS & GILCHRIST, A PROFESSIONAL
CORPORATION
1445 Ross Avenue, Suite 3200
Dallas, Texas 75202
(214) 855-4500
Attorneys For Applicant



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Dated:

07-21-04

Signature:

Carol Martin
(Carol Martin)

Docket No.: 45688-00002USPT
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Fen-Ren Chien et al.

Allowed: December 5, 2003

Application No.: 09/434318

Confirmation No.: 3814

Filed: November 4, 1999

Art Unit: 2814

For: FLIP-CHIP LIGHT-EMITTING DEVICE

Examiner: T. T. Doan

PENDING APPLICATION STATUS DISCUSSION AND INQUIRY

MS: Petitions
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Examiner and Petitions Board:

To help ensure proper issuance of the pending application, a brief explanation of recent occurrences of this application is herein provided.

During a Petition filed June 3, 2000 being pending, prosecution on the merits ensued. Upon the application being deemed allowable, a Notice of Allowance was issued December 5, 2003. On March 2, 2004, the issue fee was paid by Applicant. However, after payment of the issue fee a Decision Refusing Status under 37 CFR 1.47(b) was mailed from the Office of Petitions on April 21, 2004 in which the Petition was dismissed.

Although the issue fee has been paid, the issue of the Petition has not yet been resolved. Therefore, a renewed Petition is attached hereto to resolve the issue of the Petition. Please provide us with guidance regarding the handling of the issue fee and Notice of Allowance, as this appears to be an unusual situation.

Application No.: 09/434318
Customer No. 23932

Docket No.: 45688-00002USPT

Thank you for your consideration. Please direct answers to me at the below listed address and telephone number.

Dated: July 21, 2004

Respectfully submitted,

By

Stanley R. Moore

Registration No.: 26,958

JENKENS & GILCHRIST, A PROFESSIONAL
CORPORATION

1445 Ross Avenue, Suite 3200

Dallas, Texas 75202

(214) 855-4500

Attorneys For Applicant

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Application No.: 09/434318

Confirmation No.: 3814

Filed: November 4, 1999

Art Unit: 2814

For: FLIP-CHIP LIGHT-EMITTING DEVICE

Examiner: T. T. Doan

**AFFIDAVIT AND DECLARATION OF FACTS
OF WESLEY SHEN**

MS: Petitions
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Mr. Wesley Shen, a senior staff member of Uni Light, having personal knowledge of the facts set forth herein, hereby states and declares that:

1. I am a senior staff member of Uni Light, having a place of business at No. 165, Shan Ying Road, Kwei Shan, Taoyuan Hsien, Taiwan, R.O.C.

2. A diligent effort was made to locate and contact inventors (i) Mr. Fen-Ren Chien, and (ii) Mr. Schang-Jing Hon to request execution of a Combined Declaration and Power of Attorney and Assignment ("Filing Documents") for the patent application identified above.

3. On 3 March 2000, I called Mr. Fen-Ren Chien at 3:05 p.m and requested that he sign the Oath and Assignment of the invention which was made during his period of employment at Uni Light. Mr. Chien verbally refused to sign the Filing Documents.

4. I have contacted Uni Light employees Mr. Bor Jen Wu (Identification No. A121742228), Mr. Ethan Lin (Identification No. A122888287) and Ms. Jessy Tsai (Identification No. H222379139), who worked with Mr. Schang-Jing Hon during employment of Mr. Hon by Uni Light. None of them had knowledge of current contact information of Mr. Hon.

5a. A Post Certified Letter requesting that Fen-Ren Chien sign the filing papers was mailed to the last known address of Fen-Ren Chien on 30 June 2004. The patent application as filed was also included with the Post Certified Letter. A copy of that letter and certification is attached as Exhibit A. No response to this letter has been received.

5b. A Post Certified Letter requesting that Schang-Jing Hon sign the Filing Documents was mailed to the last known address of Schang-Jing Hon on 30 June 2004. The patent application as filed was also included with the Post Certified Letter. A copy of that letter and certification is attached as Exhibit B. No response to this letter has been received.

6a. Mr. Fen-Ren Chien's last known address is 4F, No. 36, Yu-Si Street, Yungho City, Taipei Hsien, Taiwan, R.O.C.

6b. Mr. Schang-Jing Hon's last known address is 2F, No. 8, Lane 29, Chu-Hsing Street, Pate City, Taoyuan Hsien, Taiwan, R.O.C.

7. Uni Light has rights in the subject matter of the above-referenced application.

With regard to Schang-Jing Hon, he executed an Oath and Assignment for the corresponding Taiwanese application. A copy of this Oath and Assignment was attached as Appendix E of the petition filed June 3, 2000. Moreover, Article 7 of the R.O.C. Patent Law states that "where an invention, or a new utility model or a new design is made by an employee in the performance of his job duties, the right to apply for patent or the patent right thereof shall be vested in his employer." Mr. Hon's employment with Uni Light, and specifically his work on Uni Light's invention during this time, appears to fall under the conditions of Article 7 with

regard to Uni Light's rights to the invention disclosed in the above-referenced application. A copy of Article 7 of the R.O.C. Patent Law was attached as Exhibit F of the petition filed June 3, 2000.

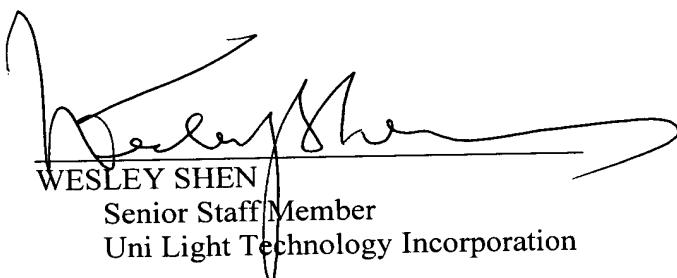
With regard to Fen-Ren Chien, Uni Light also has rights in the subject matter under Article 7 of the R.O.C. Patent Law.

A copy of related documents evidencing Uni Light's ownership of the invention, that were previously filed in the Taiwanese Intellectual Property Office, were attached as Exhibit G of the petition filed June 3, 2000.

8. Uni Light also submits that it will suffer irreparable damage should this petition not be granted and the company's interests are at stake in that a filing date is necessary to make a claim for priority based on the Taiwanese application previously filed.

9. I declare further that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States code, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

This affidavit and declaration is executed on this 16th day of July, 2004.



The image shows a handwritten signature in black ink, which appears to read "Wesley Shen". Below the signature, there is printed text identifying the signer.

WESLEY SHEN
Senior Staff Member
Uni Light Technology Incorporation

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Signature:

Carol Martin
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Docket No.: 45688-00002USPT
(PATENT)



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
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Application No.: 09/434318

Confirmation No.: 3814

Filed: November 4, 1999

Art Unit: 2814

For: FLIP-CHIP LIGHT-EMITTING DEVICE

Examiner: T. T. Doan

AFFIDAVIT AND DECLARATION OF FACTS
LIU HUN-HUANG

MS: Petitions
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Mr. Liu Hun-Huang, the responsible person and an employee of Uni Light, having personal knowledge of the facts set forth herein, hereby states and declares that:

1. I am the responsible person and an employee of Uni Light, having a place of business at No. 165, Shan Ying Road, Kwei Shan, Taoyuan Hsien, Taiwan, R.O.C.

2. A diligent effort was made to locate and contact inventors (i) Mr. Fen-Ren Chien, and (ii) Schang-Jing Hon to request execution of a Combined Declaration and Power of Attorney and Assignment ("Filing Documents") for the patent application identified above.

3a. A Post Certified Letter requesting that Fen-Ren Chien sign the filing papers was mailed to the last known address of Fen-Ren Chien on 30 June 2004. The patent application as filed was also included with the Post Certified Letter. A copy of that letter and certification is attached as Exhibit A. I have received no response to this letter.

3b. A Post Certified Letter requesting that Schang-Jing Hon sign the Filing Documents was mailed to the last known address of Schang-Jing Hon on 30 June 2004. The patent application as filed was also included with the Post Certified Letter. A copy of that letter and certification is attached as Exhibit B. I have received no response to this letter.

4a. Mr. Fen-Ren Chien's last known address is 4F, No. 36, Yu-Si Street, Yungho City, Taipei Hsien, Taiwan, R.O.C.

4b. Mr. Schang-Jing Hon's last known address is 2F, No. 8, Lane 29, Chu-Hsing Street, Pate City, Taoyuan Hsien, Taiwan, R.O.C.

5. I declare further that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true, and further that these statements are made with the knowledge that false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States code, and that such false statements may jeopardize the validity of the application or any patent issuing thereon.

This affidavit and declaration is executed on this 16th day of July, 2004.

LIU HUN-HUANG
LIU HUN-HUANG

(Translation)
A Post Certified Letter

Taipei Formosa Post Office	Sender:	Mr. Liu Hun-Huang of Uni Light Technology Incorporation
Certified No. 1680	Address:	No. 165, Shan Ying Road, Kwei Shan, Taoyuan Hsien, Taiwan, R.O.C.
	Receiver:	Mr. Fen-Ren Chien
	Address:	4F, No. 36, Yu-Si Street, Yungho City, Taipei Hsien, Taiwan, R.O.C.

Courtesy Copy:

Address:

Subject: In order to apply for a US patent application for the invention entitled "Lip-Chip Light-Emitting Device," we are writing again to request you to execute filing documents required for such application, which you have turned down once.

Explanation:

The invention entitled " Lip-Chip Light-Emitting Device" (the "Invention") was jointly made by you and Mr. Schang-Jiang Hon during the performance of your job duties at our company. Pursuant to Paragraph 1, Article 7 of the Patent Law, the right to apply for a patent on the Invention or the patent right thereof subsequently obtained shall be vested in our company. Hence, in order to apply for patents on the Invention in Taiwan, the United States, Canada, Japan and other regions, Mr. Wesley Shen, the chief of our Administration Department, called you at 3:05 pm on March 3, 2000, requesting you to sign the documents required for filing the above-mentioned patent applications. However, you declined to do as requested. Our company then sent you the March 7, 2000 Post Certified Letter No. 263 enclosed with those documents via Taoyuan Post Office, 23rd Branch and requested you to sign and mail them back by March 22, 2000. However, our company has yet to receive any of such documents or any reply from you to the Post Certified Letter. Your address "4F, No. 36, Yu-Sih Street, Yonghe City, Taipei County," which was your last known address to our company, was shown in your personnel data kept by our company. In order to consummate the filing procedure of the US patent for the Invention (USSNN

09/434,318), our company hereby sends you this letter enclosed with the following documents, hoping that you sign the following documents together with the Combined Declaration and Power of Attorney and the Assignment attached thereto and return the same to our company as soon as possible:

1. a copy of USSN 09/434,318 (Attachment 1);
2. a copy of Combined Declaration and Power of Attorney form (Attachment 2);
and
3. a copy of Assignment form (Attachment 3).

Our company hopes that you sign the Declaration Form and the Assignment Form and mail the same back to our company by July 15, 2004. If those documents are not received by our company by the said time limit, our company will establish that you remain refusing to sign those documents and will report such situations to the Trademark and Patent Office of the United States so as to consummate the filing procedure of the US patent application for the Invention.

台北台塑郵局

存證信函第

1881

四

號

一、寄件人

姓名：洲磊科技股份有限公司

劉澤煌

洋田地址：桃園縣龜山鄉山頂村山鶯路一六五號

130

台北台塑郵局 郵局										存證信函第 681 號									
一、寄件人 姓名：劉澤煌										詳細地址：桃園縣龜山鄉山頂村山鶯路一六五號									
二、收件人 姓名：簡奉任先生										詳細地址：台北縣永和市豫溪街卅六號四樓									
三、收件人本姓名： (本欄姓名、地址不敷填写時，請另紙聯記)										詳細地址：									
行格 一 主 旨 ：										行格 一 主 旨 ：									
說明 ：										為發明 。利申請， 文出事 件。函告 。本案發 一職於本 成之發明 所取得之事 利權，依期 利權，本案專 利皆屬於本 民國專利申 中華民國履行 關係於發明 一。本公司 期間因履行職務 於本公司 利及本公司 利務所共同 拒絕簽署申請 台端簽署申請 向美所件需提 十五十六十七十八十九廿									
說明 ：										Lip-Chip Light-Emitting Device Lip-Chip Light-Emitting Device									
本存證信函共 5 頁，正本 1 份，存證費元，合計 37.5 元。 副本 1 份，存證費元，合計 37.5 元。										經辦員 主管 印									
註 二、存證信函需送交郵局辦理，證明手續後始有效，自立之日起，郵局保存之副本，於三年期滿後銷燬。										印 如修改處真注本欄並蓋用 每頁至多不得逾二十字。									
備 二、在頁行第 格下塗改增刪字										郵資票或券									
四、每件一式三份，用不脫色筆或打字機複寫，或書寫後複印、影印，每格限書一字，色澤明顯、字跡端正。										處									

副正本

用函信

用函信

存證信函第

郵局

A circular red postmark from Beijing, China, featuring the Chinese characters "北京" (Beijing) at the top and "邮局" (Post Office) at the bottom. The date "1988年6月30日" (June 30, 1988) is in the center.

名

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US->998

ATTORNEY DOCKET NO.: _____

PATENT

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; and

I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: FLIP-CHIP LIGHT-EMITTING DEVICE

the specification of which:

_____ is attached hereto.

X was filed on 4 November 1999 as Application Serial No. _____
09/434,318 and was amended on _____ (if applicable)
(Attorney Docket No. _____)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to the patentability of this application as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of any application on which priority is claimed:

Country	Number	Date Filed	Priority Claimed
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose to the Office all information known to me to be material to patentability of the application as defined in 37 CFR § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (patented, pending)
_____	_____	_____

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: THOMAS L. CRISMAN, Reg. No. 24,846; THOMAS L. CANTRELL, Reg. No. 20,849; STANLEY R. MOORE, Reg. No. 26,958; H. MATHEWS GARLAND, Reg. No. 19,129; GERALD T. WELCH, Reg. No. 30,332; ROGER L. MAXWELL, Reg. No. 31,855; P. WESTON MUSSelman, JR., Reg. No. 31,644; J. KEVIN GRAY, Reg. No. 37,141; JEFFERY E. BACON, Reg. No. 35,055; STEVEN R. GREENFIELD, Reg. No. 38,166; ANDRE M. SZUWALSKI, Reg. No. 35,701; STUART D. DWORK, Reg. No. 31,103; CRAIG A. HOERSTEN, Reg. No. 38,917; RICHARD J. MOURA, Reg. No. 34,883; RICHARD L. MYSLIWIEC, Reg. No. 40,098; and RAYMOND VAN DYKE, Reg. No. 34,746, of the firm of JENKENS & GILCHRIST, 3200 Fountain Place, 1445 Ross Avenue, Dallas, Texas 75202-2799; and

Address all telephone calls and correspondence to:

Stanley R. Moore, Esq.
Jenkens & Gilchrist, P.C.
3200 Fountain Place
1445 Ross Avenue
Dallas, Texas 75202-2799
214/855-4500

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1	FEN-REN CHIEN Full Name	<input checked="" type="checkbox"/> Inventor's Signature	<input checked="" type="checkbox"/> Date
	NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C. Residence	TAIWAN, R.O.C. <input checked="" type="checkbox"/> Citizenship	
	SAME AS ABOVE Post Office Address		
2	SCHANG-JING HON Full Name	<input checked="" type="checkbox"/> Inventor's Signature	<input checked="" type="checkbox"/> Date
	NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C. Residence	TAIWAN, R.O.C. <input checked="" type="checkbox"/> Citizenship	
	SAME AS ABOVE Post Office Address		
3	Full Name	<input checked="" type="checkbox"/> Inventor's Signature	<input checked="" type="checkbox"/> Date
	Residence	<input checked="" type="checkbox"/> Citizenship	
	Post Office Address		
4	Full Name	<input checked="" type="checkbox"/> Inventor's Signature	<input checked="" type="checkbox"/> Date
	Residence	<input checked="" type="checkbox"/> Citizenship	
	Post Office Address		



INSTRUCTIONS

US->98

ASSIGNMENT OF U.S. RIGHTS TO CORPORATION

Inventor(s)
Name,
Address,
Citizenship

WHEREAS,
1. FEN-REN CHIEN residing at NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C.
and a citizen of TAIWAN, R.O.C.
2. SCHANG-JING HON residing at NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C.
and a citizen of TAIWAN, R.O.C.
3. _____ residing at _____
and a citizen of _____

Date Patent
Declaration
Signed and
Title

(herein called "THE UNDERSIGNED") have made an invention and have executed an application for Letters Patent of the United States on _____ for this invention, which application is entitled FLIP-CHIP LIGHT-EMITTING DEVICE and which has been given

Serial No. and
Filing Date

Serial Number 09/434,318

and the filing date of 4 November 1999

Name of
Corporation

AND WHEREAS UNI LIGHT TECHNOLOGY INCORPORATION (herein called "ASSIGNEE"), a corporation organized under the laws of TAIWAN, R.O.C., and having an office and place of business at NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C.,

State or
Country of
Incorporation
and Address

wishes to acquire the entire right, title and interest in and to said invention and patent application and any Letters Patent to be obtained therefor;

NOW, THEREFORE, for and in consideration of the sum of One Dollar and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, THE UNDERSIGNED hereby sell, assign and transfer to the ASSIGNEE, its successors and assigns, the entire right, title and interest for the United States in and to the invention disclosed in the aforesaid application, and in and to the said application, all divisions, continuations, or renewals thereof, all Letters Patent which may be granted therefrom, and all reissues or extensions of such patents, and THE UNDERSIGNED hereby authorize and request the Commissioner of Patents to issue any and all United States Letters Patent for the aforesaid invention to the ASSIGNEE of the entire right, title and interest in and to the same, for the use of the ASSIGNEE, its successors and assigns.

THE UNDERSIGNED hereby agree that THE UNDERSIGNED, their executors and legal representatives will make, execute and deliver (without charge but at the expense of the ASSIGNEE) any and all other instruments in writing including any and all further application papers, affidavits, assignments and other documents, and will communicate to said ASSIGNEE, its successors and representatives all facts known to THE UNDERSIGNED relating to said invention and the history thereof and will testify in all legal proceedings and generally do all things which may be necessary or desirable to vest the ASSIGNEE, its successors or assigns the entire right, title and interest in and to the said invention, applications, Letters Patent, rights, titles, benefits, privileges and advantages hereby sold, assigned and conveyed, or intended so to be.

THE UNDERSIGNED represent and agree with said ASSIGNEE, its successors and assigns, that no assignment grant, mortgage, license or other agreement affecting the rights and property herein conveyed has been or will be made to others by THE UNDERSIGNED, and that full right to convey the same as herein expressed is possessed by THE UNDERSIGNED.

IN TESTIMONY WHEREOF, THE UNDERSIGNED have hereunto set their hand on the dates indicated below.

Each Inventor
Must Sign
and Date

Signature FEN-REN CHIEN

✓
Date

Note: No
Legalization or
Other Witness
Required

Signature SCHANG-JING HON

✓
Date

Signature

✓
Date

Flip-chip Light-emitting Device

Field of the Invention

The present invention relates to a gallium nitride (GaN)-based light-emitting device and, particularly, to a GaN-based light-emitting device having an electrode with good reflectivity of light.

Background of the Invention

GaN-based light-emitting devices are getting more attention for the reason that they can emit special frequencies of light, such as blue light and green light. The material of substrate used for GaN-based light emitting devices is limited by the property of GaN and is mainly chosen from the following material: sapphire, silicon carbide (SiC), gallium nitride (GaN), gallium phosphide (GaP) and glass. Among the above material, sapphire substrate is widely used. Since sapphire substrate is an insulator, the two electrodes of the light-emitting device must be placed on the same side of the GaN layers. It is the characteristic of so-called lateral devices. USP 5,563,422, USP 5,578,839 and USP 5,583,879 have disclosed a series of methods for manufacturing GaN-based III-V Group compound semiconductor lateral light-emitting devices using sapphire substrate. The light-emitting device manufactured therefrom is shown in Fig. 1, wherein an light-emitting diode (LED) die 10 is fixed to a lead frame 12 first, and the two electrodes 13 and 14 on the upper surface of the die 10 must be soldered with gold (or aluminium) wires 15 and 16 respectively so as to be connected to the two electrodes of the lead frame. However, the soldering pad 17 on the upper surface of the die 10 will block the light, and thus the light-emitting area is reduced and the light emitted is not uniform. In addition, in the prior light-emitting device, a light-transmitting electrode 13 is disclosed for providing the

effect of current spreading to enhance the light-emitting efficiency of the device. However, since the electrode 13 must be very thin to become light-transmitting, its lateral resistance will be great and thus its effect of current spreading will be very limited. Besides, since the electrode 13 is placed over the main light-emitting surface, even the electrode 13 is light-transmissive, it still will reduce the light-emitting efficiency of the device.

USP 4,476,620 discloses a flip-chip GaN-based light-emitting device as shown in Fig. 2, wherein the two electrodes 21 and 22 of an LED die are directly stuck on certain places of a lead frame 23. In such a flip-chip GaN-based light-emitting device, the emitted light can directly pass through the transparent substrate (such as a sapphire substrate) to the outside. There is no soldering pad in the main light-emitting surface of the flip-chip light-emitting device, and thus the light-emitting surface as well as the light-emitting efficiency will not be affected by the soldering pad. However, only about half the light emitted from the prior flip-chip GaN-based light-emitting device can directly pass through the transparent substrate to the outside. The other half of the light is directed to the electrodes (21 and 22) and the lead frame 23. Therefore, the prior device cannot achieve an effective result. Furthermore, the prior flip-chip GaN-based light-emitting device disclosed in USP 4,476,620 does not provide the current spreading effect, and thus merely the place where the electrode is located can have an effective light-emitting result while the other place cannot achieve a good light-emitting result.

In view of the above, how to substantially improve the light-emitting efficiency of a GaN-based light-emitting device is still a problem for the industry.

Summary of the Invention

The main object of the present invention is to substantially improve the light-emitting efficiency of a GaN-based light-emitting device. The light-emitting device according to the present invention is a flip-chip light-emitting device.

Therefore, there is no soldering pad in its main light-emitting surface. Additionally, the light-emitting device according to the present invention has an electrode that has good reflectivity of light and can provide effective current spreading effect. Therefore, the light directed to the electrode can be reflected by the electrode to the outside through the transparent substrate, and thus substantially increase the light-emitting efficiency of the whole device. Further, the electrode can have sufficient size and thickness to provide effective current spreading effect, such that the light-emitting diode can achieve its best light-emitting result.

A flip-chip light-emitting device according to a first embodiment of the present invention comprises a transparent substrate, a semiconductor stacked structure arranged over a main surface of the transparent substrate wherein the stacked structure comprises an n-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a p-type GaN-based III-V Group compound semiconductor layer adjacent to the n-type semiconductor layer, a first electrode being in electrical contact with the n-type semiconductor layer, and a second electrode being in electrical contact with the p-type semiconductor layer, wherein the second electrode has good reflectivity of light and covers most of the outer surface of the p-type semiconductor layer. In an alternative embodiment of the present invention, the positions of the n-type and p-type semiconductor layers are switched, and the electrode being in contact with the n-type semiconductor layer has good reflectivity of light and covers most outer surface of the n-type semiconductor layer.

Brief Description of the Drawings

The technical content and features of the present invention will be more readily apparent from the following detailed description of the preferred embodiments with reference to the accompanying drawings in which:

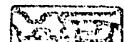
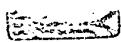


Fig. 1 is a cross-sectional view illustrating a prior GaN-based light-emitting device;

Fig. 2 is a cross-sectional view illustrating a prior flip-chip GaN-based light-emitting device;

Fig. 3 is a schematic cross-sectional view illustrating a light-emitting diode according to an embodiment of the present invention;

Fig. 4 is a schematic cross-sectional view of the light-emitting diode of Fig. 3 mounted on a base in the form of flip-chip.

Detailed Description of the Preferred Embodiments

The main object of the present invention is to substantially improve the light-emitting efficiency of a GaN-based light-emitting device. The light-emitting device according to the present invention has an electrode that has good reflectivity of light and can provide effective current spreading effect. Therefore, the light directed to the electrode can be reflected by the electrode to the outside, and thus substantially increase the light-emitting efficiency of the whole device. Further, the electrode can have sufficient size and thickness to provide effective current spreading effect, so that the light-emitting diode can achieve its best light-emitting result.

Fig. 3 illustrates a light-emitting diode according to an embodiment of the present invention. The diode structure 30 comprises a transparent substrate 31 which can be made of sapphire, glass, silicon carbide (SiC), gallium nitride (GaN), gallium phosphide (GaP) or other transparent materials. A semiconductor stacked structure is arranged over a main surface of the transparent substrate 31. The stacked structure comprises an n-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a p-type GaN-based III-V Group compound semiconductor layer adjacent to the n-type semiconductor layer. In this embodiment, the stacked structure also comprises an active layer 34



placed between the n-type GaN-based III-V Group compound semiconductor layer and the p-type GaN-based III-V Group compound semiconductor layer, while in other embodiments of the present invention, it is possible that the stacked structure does not include the active layer 34. The method for manufacturing the stacked structure is well known in the art, and thus it is unnecessary to detail it here. An electrode 35 is located in a window, that is formed by an etching process, and in electrical contact with the n-type semiconductor layer 32. An electrode 36 is arranged over most of the outer surface of the p-type semiconductor layer 33. Since there are no special limitations on the size and thickness of the electrode 36, the shape and size of the electrode 36 can be designed to achieve the best current spreading result, and thus substantially increase the light-emitting efficiency. In addition, the material of the electrode 36 is chosen to be of high reflectivity of light. Therefore, the light directed to the electrode 36 can be reflected by the electrode 36 to the direction of the transparent substrate, and thus further increase the light-emitting efficiency.

In the present invention, the electrode 36 can be of a multi-layer structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag). In an embodiment of the present invention, the electrode 36 can be of a nickel/gold/titanium/aluminium (Ni/Au/Ti/Al) multi-layer structure, wherein nickel/gold (Ni/Au) is formed to be a light-transmitting metal layer directly covering the p-type semiconductor layer 33, and than a titanium (Ti) layer is formed on the Ni/Au layer, and finally an aluminium (Al) layer is formed on the Ti layer. The electrode 36 is required to be of both low ohmic contact resistance and high reflectivity of light. Ni/Au is one of the materials that can be formed as a good light-transmitting ohmic contact layer for a p-type GaN-based III-V Group compound semiconductor layer. Al layer can be of good reflectivity of light. However, in a high temperature, Al and Au will diffuse into each other and destroy the reflectivity of Al. Therefore a Ti layer is used to be a diffusion barrier

between Al and Au. Ti layer itself is also of good reflectivity of light. In other embodiments of the present invention, the electrode 36 can be of a multi-layer structure of ITO/Al or ITO/Ag, wherein ITO (Indium-Tin Oxide) is formed as a light-transmitting conductive layer and the reflectivity is provided by the Al layer or Ag layer.

In the embodiment shown in Fig. 3, an insulating layer 37 can be coated on the side surface and upper surface of the diode 30 while merely exposing a portion of each electrode that is used to contact the electrode of a base. The material of the insulating layer can be SiO_x , SiN_y , etc.. The insulating layer 37 is to protect and isolate the p/n junction, to avoid short circuit caused by conductive glue and to avoid leakage.

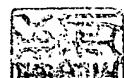
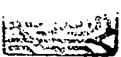
Fig. 4 is a schematic view showing the light-emitting diode of Fig. 3 mounted on a base in the form of flip-chip. The base 40 can be a known conductive lead frame, a glass lead frame, a circuit board or a thin-film circuit. Using a conductive lead frame or a glass lead frame as the base, the final device will be a discrete light-emitting device, while using a circuit board or a thin-film circuit as the base, the light-emitting device will be in the form of surface mounted device (SMD). The base 40 has conductive portions 41 and 42 that function as a positive electrode and a negative electrode, respectively. Conductive glue 43 is applied by a machine on the positive and negative electrodes of the base 40. Then, the light-emitting diode 30 is turned over to let the transparent substrate be the top layer and the electrodes 35 and 36 face down. After determining the correct polarities of the electrodes 35 and 36, the electrodes 35 and 36 are connected to the conductive glue 43 so as to be fixed on the base and be coupled to the electrodes of the base. Finally, the conductive glue is baked in a suitable temperature during a predetermined time to complete the manufacture of the light-emitting device.

In this embodiment, about half of the light emitted from the p-n junction or the

active layer of the light-emitting device will directly pass through the transparent substrate to the outside, while the other half of the light will direct to the electrode 36. Since the electrode 36 has high efficiency of reflectivity, it can reflect the light through the transparent substrate to the outside, and thus increase the light-emitting efficiency. Further, the electrode 36 provides the current spreading effect to additionally increase the light-emitting efficiency of the light-emitting diode.

In other embodiments of the present invention, the places of the n-type semiconductor layer and the p-type semiconductor layer can be exchanged. In such embodiments, the electrode over the n-type semiconductor layer will be of high reflectivity of light and provides current spreading effect. Said electrode can be of a multi-layer structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag). In embodiments of the present invention, said electrode can be of a multi-layer structure of Ti/Al, Ti/Ag, ITO/Al or ITO/Ag.

The technical features and technical contents of the present invention have been fully disclosed as above. However, various modifications or replacements can be made by people skilled in the art based on the disclosure and teaching of the present invention without departing the spirit of the present invention. Therefore, the scope of the present invention shall not be limited to the above disclosed embodiments and should include said modifications and replacements.



What is claimed is:

1. A flip-chip light-emitting device, comprising
a transparent substrate;
a semiconductor stacked structure arranged over a main surface of said transparent substrate wherein said stacked structure comprises an n-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a p-type GaN-based III-V Group compound semiconductor layer adjacent to said n-type semiconductor layer;
a first electrode being in electrical contact with said n-type semiconductor layer; and
a second electrode being in electrical contact with said p-type semiconductor layer;
wherein said second electrode has good reflectivity of light and covers most of the outer surface of said p-type semiconductor layer.
2. The device of Claim 1 wherein said stacked structure further comprises an active layer placed between said n-type semiconductor layer and said p-type semiconductor layer.
3. The device of Claims 1 or 2 further comprising an insulating layer at least coated on the side surface of the stacked structure, a portion of said first electrode and a portion of said second electrode.
4. The device of Claims 1 or 2 further comprising a base which has a first and a second conductive portions respectively connected to said first and second electrodes.
5. The device of Claim 4 wherein said base can be a conductive lead frame, a glass lead frame, a circuit board or a thin-film circuit.
6. The device of Claims 1 or 2 wherein said second electrode is a multi-layer structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag).

7. The device of Claims 1 or 2 wherein said second electrode is a multi-layer structure of nickel/gold/titanium/aluminium (Ni/Au/Ti/Al), Indium-Tin Oxide/aluminium (ITO/Al) or Indium-Tin Oxide/silver (ITO/Ag).
8. A flip-chip light-emitting device, comprising
a transparent substrate;
a semiconductor stacked structure arranged over a main surface of said transparent substrate wherein said stacked structure comprises an p-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a n-type GaN-based III-V Group compound semiconductor layer adjacent to said p-type semiconductor layer;
a first electrode being in electrical contact with said n-type semiconductor layer; and
a second electrode being in electrical contact with said p-type semiconductor layer;
wherein said first electrode has good reflectivity of light and covers most of the outer surface of said n-type semiconductor layer.
9. The device of Claim 8 wherein said stacked structure further comprises an active layer placed between said n-type semiconductor layer and the p-type semiconductor layer.
10. The device of Claims 8 or 9 further comprising an insulating layer at least coated on the side surface of the stacked structure, a portion of said first electrode and a portion of said second electrode.
11. The device of Claims 8 or 9 further comprising a base which has a first and a second conductive portions respectively connected to said first and second electrodes.
12. The device of Claim 11 wherein said base can be a conductive lead frame, a glass lead frame, a circuit board or a thin-film circuit.
13. The device of Claims 8 or 9 wherein said second electrode is a multi-layer

structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag).

14. The device of Claims 8 or 9 wherein said second electrode is a multi-layer structure of titanium/aluminium (Ti/Al), titanium/silver (Ti/Ag), Indium-Tin Oxide/aluminium (ITO/Al) or Indium-Tin Oxide/silver (ITO/Ag).

Abstract

The present invention discloses a flip-chip light-emitting device that has improved light-emitting efficiency. The device according to the present invention has an electrode with good reflectivity of light, such that the light directed to the base can be reflected by the electrode to the outside, and thus substantially increase the light-emitting efficiency. In addition, said electrode of the present invention also provide better current spreading effect, and thus further increase the light-emitting efficiency of the light-emitting diode.

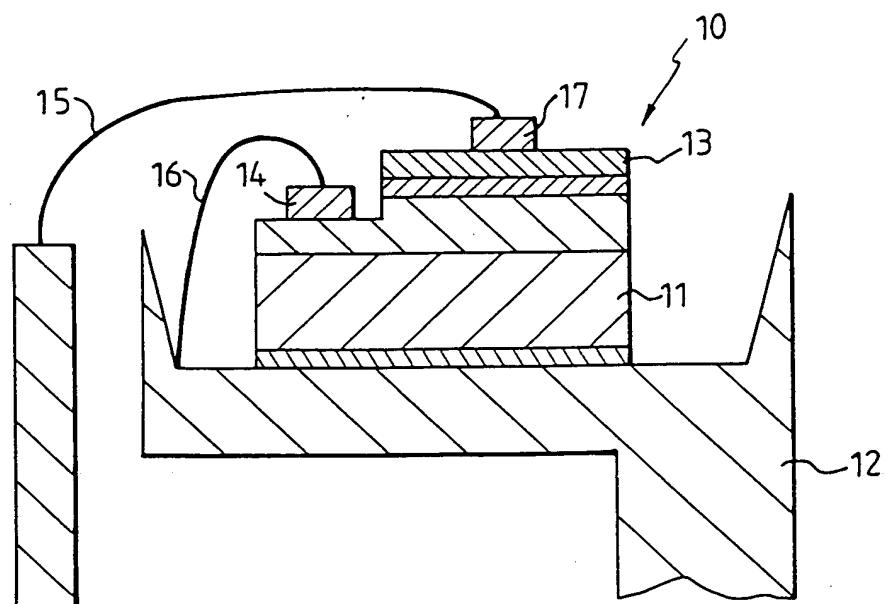


FIG. 1
(Prior Art)

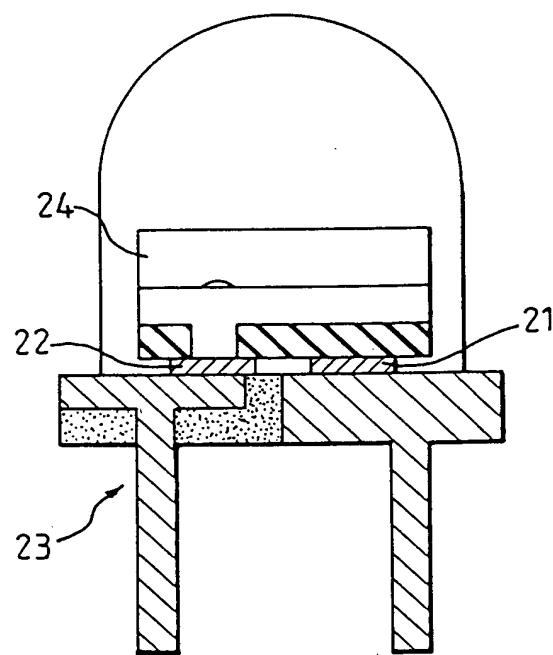


FIG. 2
(Prior Art)

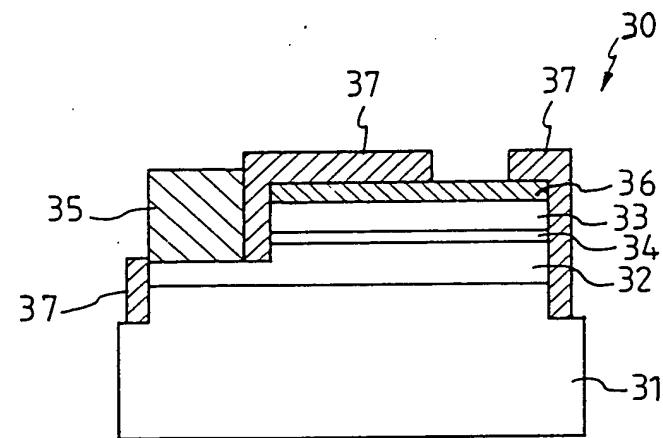


FIG. 3

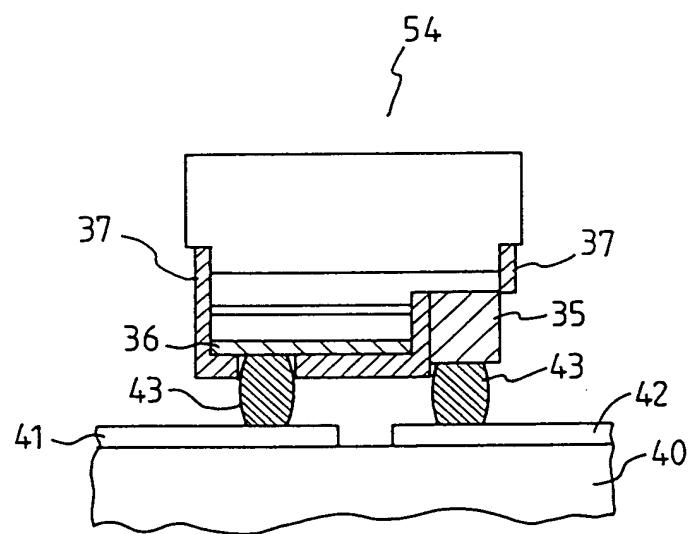


FIG. 4

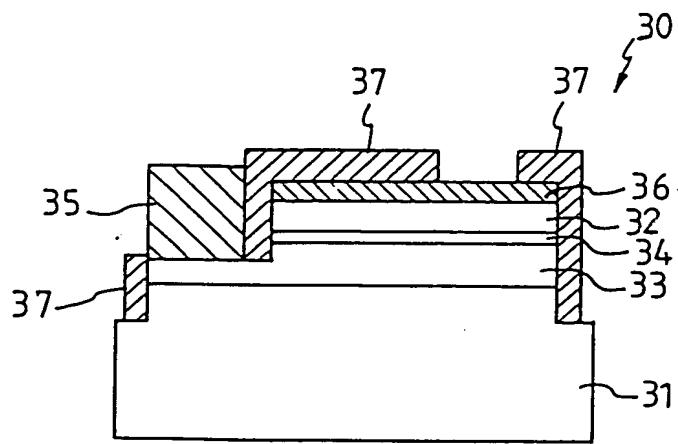


FIG. 5

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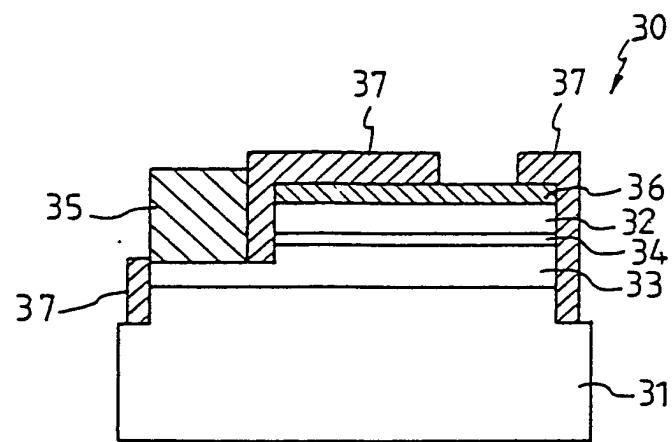


FIG. 5

(Translation)
A Post Certified Letter

Taipei Formosa Post Office

Sender: Mr. Liu Hun-Huang of Uni Light
Technology Incorporation

Certified No. 1680

Address: No. 165, Shan Ying Road, Kwei Shan,
Taoyuan Hsien, Taiwan, R.O.C.

Receiver: Mr. Schang-Jiang Hon

Address: 2F, No. 8, Lane 29, Chu-Hsing Street,
Pate City, Taoyuan, Hsien, Taiwan,
R.O.C.

Courtesy Copy:

Address:

Subject: In order to file a US patent application for the invention entitled "Lip-chip Light-emitting Device," we are writing again to request you to execute filing documents required for such application, which you have turned down once.

Explanation:

The invention entitled " Lip-chip Light-emitting Device " (the "Invention") was jointly made by you and Mr. Fen-Ren Chien during the performance of your job duties at our company. Pursuant to Paragraph 1, Article 7 of the Patent Law, the right to apply for a patent on the Invention or the patent right thereof subsequently obtained shall be vested in our company. Hence, in order to apply for patents on the Invention in Taiwan, the United States, Canada, Japan and other regions, Mr. Wesley Shen, the chief of our Administration Department, called Mr. Fen-Ren Chien at 3:05 pm on March 3, 2000, requesting Mr. Chien to sign the documents required for filing the above-mentioned patent applications. However, Mr. Chien declined to do so as requested. Our company then sent you the March 7, 2000 Post Certified Letter No. 262 enclosed with those documents via Taoyuan Post Office, 23rd Branch and requested you to sign and mail them back by March 22, 2000. We only received from you the documents required for filing patent application in the ROC (Taiwan), but not include the documents required for filing patent application in the USA for the subject the Invention. Your address "2F, No. 8, Lane 29, Chu-Hsing Street, Pate City, Taoyuan, Hsien, Taiwan, R.O.C.," which was your last known address to our

company, was shown in your personnel data kept by our company. In order to consummate the filing procedure of the US patent application for the Invention (USSNN 09/434,318), our company hereby sends you this letter enclosed with the following documents, hoping that you sign the following documents together with the Combined Declaration and Power of Attorney and the Assignment attached thereto and return the same to our company as soon as possible:

1. a copy of USSN 09/434,318 (Attachment 1);
2. a copy of Combined Declaration and Power of Attorney form (Attachment 2);
and
3. a copy of Assignment form (Attachment 3).

Our company hopes that you sign the Combined Declaration and Power of Attorney and the Assignment Forms and mail the same back to our company by July 15, 2004. If those documents are not received by our company by the said time limit, our company will establish that you remain refusing to sign those documents and will report such situations to the Trademark and Patent Office of the United States so as to consummate the filing procedure of the US patent application for the Invention.

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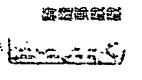
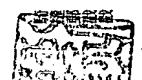
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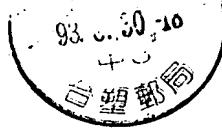
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[印]如有修改應填註本欄並蓋用
寄件人印章，但塗改增刪
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US-2292

ATTORNEY DOCKET NO.: _____

PATENT

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; and

I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: FLIP-CHIP LIGHT-EMITTING DEVICE

the specification of which:

____ is attached hereto.

X was filed on 4 November 1999 as Application Serial No. 09/434,318 and was amended on _____ (if applicable)
(Attorney Docket No. _____.)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to the patentability of this application as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of any application on which priority is claimed:

Country	Number	Date Filed	Priority Claimed
_____	_____	_____	_____
_____	_____	_____	_____

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose to the Office all information known to me to be material to patentability of the application as defined in 37 CFR § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (patented, pending)
_____	_____	_____

60

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: THOMAS L. CRISMAN, Reg. No. 24,846; THOMAS L. CANTRELL, Reg. No. 20,849; STANLEY R. MOORE, Reg. No. 26,958; H. MATHEWS GARLAND, Reg. No. 19,129; GERALD T. WELCH, Reg. No. 30,332; ROGER L. MAXWELL, Reg. No. 31,855; P. WESTON MUSSELMAN, JR., Reg. No. 31,644; J. KEVIN GRAY, Reg. No. 37,141; JEFFERY E. BACON, Reg. No. 35,055; STEVEN R. GREENFIELD, Reg. No. 38,156; ANDRE M. SZUWALSKI, Reg. No. 35,701; STUART D. DWORK, Reg. No. 31,103; CRAIG A. HOERSTEN, Reg. No. 38,917; RICHARD J. MOURA, Reg. No. 34,883; RICHARD L. MYSLIWIEC, Reg. No. 40,098; and RAYMOND VAN DYKE, Reg. No. 34,746, of the firm of JENKENS & GILCHRIST, 3200 Fountain Place, 1445 Ross Avenue, Dallas, Texas 75202-2799; and

Address all telephone calls and correspondence to:

Stanley R. Moore, Esq.
Jenkens & Gilchrist, P.C.
3200 Fountain Place
1445 Ross Avenue
Dallas, Texas 75202-2799
214/855-4500

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

	FEN-REN CHIEN Full Name	X Inventor's Signature	V Date
1	NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C. Residence	2 TAIWAN, R.O.C. Citizenship	
	Post Office Address SAME AS ABOVE		
	SCHANG-JING HON Full Name	X Inventor's Signature	V Date
2	NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C. Residence	TAIWAN, R.O.C. Citizenship	
	Post Office Address SAME AS ABOVE		
	Full Name	Inventor's Signature	Date
3	Residence	Citizenship	
	Post Office Address		
	Full Name	Inventor's Signature	Date
4	Residence	Citizenship	
	Post Office Address		

INSTRUCTIONS

ASSIGNMENT OF U.S. RIGHTS TO CORPORATION

US-2298

WHEREAS,

1. FEN-REN CHIEN residing at NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C. and a citizen of TAIWAN, R.O.C.
2. SCHANG-JING HON residing at NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C. and a citizen of TAIWAN, R.O.C.
3. _____ residing at _____

Inventor(s)
Name,
Address,
CitizenshipDate Patent
Declaration
Signed and
TitleSerial No. and
Filing DateName of
CorporationState or
Country of
Incorporation
and Address

► (herein called "THE UNDERSIGNED") have made an invention and have executed an application for Letters Patent of the United States on _____ for this invention, which application is entitled FLIP-CHIP LIGHT-EMITTING DEVICE

► Serial Number 09/434,318 and the filing date of 4 November 1999

► AND WHEREAS UNI LIGHT TECHNOLOGY INCORPORATION (herein called "ASSIGNEE"), a corporation organized under the laws of TAIWAN, R.O.C., and having an office and place of business at NO. 165, SHAN YING RD., SHAN DING VILL., KWEI SHAN, TAOYUAN HSIEN, TAIWAN, R.O.C.

wishes to acquire the entire right, title and interest in and to said invention and patent application and any Letters Patent to be obtained therefor;

NOW, THEREFORE, for and in consideration of the sum of One Dollar and other good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, THE UNDERSIGNED hereby sell, assign and transfer to the ASSIGNEE, its successors and assigns, the entire right, title and interest for the United States in and to the invention disclosed in the aforesaid application, and in and to the said application, all divisions, continuations, or renewals thereof, all Letters Patent which may be granted therefrom, and all reissues or extensions of such patents, and THE UNDERSIGNED hereby authorize and request the Commissioner of Patents to issue any and all United States Letters Patent for the aforesaid invention to the ASSIGNEE of the entire right, title and interest in and to the same, for the use of the ASSIGNEE, its successors and assigns.

THE UNDERSIGNED hereby agree that THE UNDERSIGNED, their executors and legal representatives will make, execute and deliver (without charge but at the expense of the ASSIGNEE) any and all other instruments in writing including any and all further application papers, affidavits, assignments and other documents, and will communicate to said ASSIGNEE, its successors and representatives all facts known to THE UNDERSIGNED relating to said invention and the history thereof and will testify in all legal proceedings and generally do all things which may be necessary or desirable to vest the ASSIGNEE, its successors or assigns the entire right, title and interest in and to the said invention, applications, Letters Patent, rights, titles, benefits, privileges and advantages hereby sold, assigned and conveyed, or intended so to be.

THE UNDERSIGNED represent and agree with said ASSIGNEE, its successors and assigns, that no assignment grant, mortgage, license or other agreement affecting the rights and property herein conveyed has been or will be made to others by THE UNDERSIGNED, and that full right to convey the same as herein expressed is possessed by THE UNDERSIGNED.

IN TESTIMONY WHEREOF, THE UNDERSIGNED have hereunto set their hand on the dates indicated below.

Each Inventor
Must Sign
and DateNote: No
Legalization or
Other Witness
RequiredSignature FEN-REN CHIENSignature SCHANG-JING HON

Signature

Date

Date

Date

34-298

Flip-chip Light-emitting Device

Field of the Invention

The present invention relates to a gallium nitride (GaN)-based light-emitting device and, particularly, to a GaN-based light-emitting device having an electrode with good reflectivity of light.

Background of the Invention

GaN-based light-emitting devices are getting more attention for the reason that they can emit special frequencies of light, such as blue light and green light. The material of substrate used for GaN-based light emitting devices is limited by the property of GaN and is mainly chosen from the following material: sapphire, silicon carbide (SiC), gallium nitride (GaN), gallium phosphide (GaP) and glass. Among the above material, sapphire substrate is widely used. Since sapphire substrate is an insulator, the two electrodes of the light-emitting device must be placed on the same side of the GaN layers. It is the characteristic of so-called lateral devices. USP 5,563,422, USP 5,578,839 and USP 5,583,879 have disclosed a series of methods for manufacturing GaN-based III-V Group compound semiconductor lateral light-emitting devices using sapphire substrate. The light-emitting device manufactured therefrom is shown in Fig. 1, wherein an light-emitting diode (LED) die 10 is fixed to a lead frame 12 first, and the two electrodes 13 and 14 on the upper surface of the die 10 must be soldered with gold (or aluminium) wires 15 and 16 respectively so as to be connected to the two electrodes of the lead frame. However, the soldering pad 17 on the upper surface of the die 10 will block the light, and thus the light-emitting area is reduced and the light emitted is not uniform. In addition, in the prior light-emitting device, a light-transmitting electrode 13 is disclosed for providing the

effect of current spreading to enhance the light-emitting efficiency of the device. However, since the electrode 13 must be very thin to become light-transmitting, its lateral resistance will be great and thus its effect of current spreading will be very limited. Besides, since the electrode 13 is placed over the main light-emitting surface, even the electrode 13 is light-transmissive, it still will reduce the light-emitting efficiency of the device.

USP 4,476,620 discloses a flip-chip GaN-based light-emitting device as shown in Fig. 2, wherein the two electrodes 21 and 22 of an LED die are directly stuck on certain places of a lead frame 23. In such a flip-chip GaN-based light-emitting device, the emitted light can directly pass through the transparent substrate (such as a sapphire substrate) to the outside. There is no soldering pad in the main light-emitting surface of the flip-chip light-emitting device, and thus the light-emitting surface as well as the light-emitting efficiency will not be affected by the soldering pad. However, only about half the light emitted from the prior flip-chip GaN-based light-emitting device can directly pass through the transparent substrate to the outside. The other half of the light is directed to the electrodes (21 and 22) and the lead frame 23. Therefore, the prior device cannot achieve an effective result. Furthermore, the prior flip-chip GaN-based light-emitting device disclosed in USP 4,476,620 does not provide the current spreading effect, and thus merely the place where the electrode is located can have an effective light-emitting result while the other place cannot achieve a good light-emitting result.

In view of the above, how to substantially improve the light-emitting efficiency of a GaN-based light-emitting device is still a problem for the industry.

Summary of the Invention

The main object of the present invention is to substantially improve the light-emitting efficiency of a GaN-based light-emitting device. The light-emitting device according to the present invention is a flip-chip light-emitting device.

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Therefore, there is no soldering pad in its main light-emitting surface. Additionally, the light-emitting device according to the present invention has an electrode that has good reflectivity of light and can provide effective current spreading effect. Therefore, the light directed to the electrode can be reflected by the electrode to the outside through the transparent substrate, and thus substantially increase the light-emitting efficiency of the whole device. Further, the electrode can have sufficient size and thickness to provide effective current spreading effect, such that the light-emitting diode can achieve its best light-emitting result.

A flip-chip light-emitting device according to a first embodiment of the present invention comprises a transparent substrate, a semiconductor stacked structure arranged over a main surface of the transparent substrate wherein the stacked structure comprises an n-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a p-type GaN-based III-V Group compound semiconductor layer adjacent to the n-type semiconductor layer, a first electrode being in electrical contact with the n-type semiconductor layer, and a second electrode being in electrical contact with the p-type semiconductor layer, wherein the second electrode has good reflectivity of light and covers most of the outer surface of the p-type semiconductor layer. In an alternative embodiment of the present invention, the positions of the n-type and p-type semiconductor layers are switched, and the electrode being in contact with the n-type semiconductor layer has good reflectivity of light and covers most outer surface of the n-type semiconductor layer.

Brief Description of the Drawings

The technical content and features of the present invention will be more readily apparent from the following detailed description of the preferred embodiments with reference to the accompanying drawings in which:

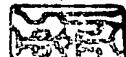
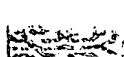


Fig. 1 is a cross-sectional view illustrating a prior GaN-based light-emitting device;

Fig. 2 is a cross-sectional view illustrating a prior flip-chip GaN-based light-emitting device;

Fig. 3 is a schematic cross-sectional view illustrating a light-emitting diode according to an embodiment of the present invention;

Fig. 4 is a schematic cross-sectional view of the light-emitting diode of Fig. 3 mounted on a base in the form of flip-chip.

Detailed Description of the Preferred Embodiments

The main object of the present invention is to substantially improve the light-emitting efficiency of a GaN-based light-emitting device. The light-emitting device according to the present invention has an electrode that has good reflectivity of light and can provide effective current spreading effect. Therefore, the light directed to the electrode can be reflected by the electrode to the outside, and thus substantially increase the light-emitting efficiency of the whole device. Further, the electrode can have sufficient size and thickness to provide effective current spreading effect, so that the light-emitting diode can achieve its best light-emitting result.

Fig. 3 illustrates a light-emitting diode according to an embodiment of the present invention. The diode structure 30 comprises a transparent substrate 31 which can be made of sapphire, glass, silicon carbide (SiC), gallium nitride (GaN), gallium phosphide (GaP) or other transparent materials. A semiconductor stacked structure is arranged over a main surface of the transparent substrate 31. The stacked structure comprises an n-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a p-type GaN-based III-V Group compound semiconductor layer adjacent to the n-type semiconductor layer. In this embodiment, the stacked structure also comprises an active layer 34

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placed between the n-type GaN-based III-V Group compound semiconductor layer and the p-type GaN-based III-V Group compound semiconductor layer, while in other embodiments of the present invention, it is possible that the stacked structure does not include the active layer 34. The method for manufacturing the stacked structure is well known in the art, and thus it is unnecessary to detail it here. An electrode 35 is located in a window, that is formed by an etching process, and in electrical contact with the n-type semiconductor layer 32. An electrode 36 is arranged over most of the outer surface of the p-type semiconductor layer 33. Since there are no special limitations on the size and thickness of the electrode 36, the shape and size of the electrode 36 can be designed to achieve the best current spreading result, and thus substantially increase the light-emitting efficiency. In addition, the material of the electrode 36 is chosen to be of high reflectivity of light. Therefore, the light directed to the electrode 36 can be reflected by the electrode 36 to the direction of the transparent substrate, and thus further increase the light-emitting efficiency.

In the present invention, the electrode 36 can be of a multi-layer structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag). In an embodiment of the present invention, the electrode 36 can be of a nickel/gold/titanium/aluminium (Ni/Au/Ti/Al) multi-layer structure, wherein nickel/gold (Ni/Au) is formed to be a light-transmitting metal layer directly covering the p-type semiconductor layer 33, and than a titanium (Ti) layer is formed on the Ni/Au layer, and finally an aluminium (Al) layer is formed on the Ti layer. The electrode 36 is required to be of both low ohmic contact resistance and high reflectivity of light. Ni/Au is one of the materials that can be formed as a good light-transmitting ohmic contact layer for a p-type GaN-based III-V Group compound semiconductor layer. Al layer can be of good reflectivity of light. However, in a high temperature, Al and Au will diffuse into each other and destroy the reflectivity of Al. Therefore a Ti layer is used to be a diffusion barrier

between Al and Au. Ti layer itself is also of good reflectivity of light. In other embodiments of the present invention, the electrode 36 can be of a multi-layer structure of ITO/Al or ITO/Ag, wherein ITO (Indium-Tin Oxide) is formed as a light-transmitting conductive layer and the reflectivity is provided by the Al layer or Ag layer.

In the embodiment shown in Fig. 3, an insulating layer 37 can be coated on the side surface and upper surface of the diode 30 while merely exposing a portion of each electrode that is used to contact the electrode of a base. The material of the insulating layer can be SiO_x , SiN_y , etc.. The insulating layer 37 is to protect and isolate the p/n junction, to avoid short circuit caused by conductive glue and to avoid leakage.

Fig. 4 is a schematic view showing the light-emitting diode of Fig. 3 mounted on a base in the form of flip-chip. The base 40 can be a known conductive lead frame, a glass lead frame, a circuit board or a thin-film circuit. Using a conductive lead frame or a glass lead frame as the base, the final device will be a discrete light-emitting device, while using a circuit board or a thin-film circuit as the base, the light-emitting device will be in the form of surface mounted device (SMD). The base 40 has conductive portions 41 and 42 that function as a positive electrode and a negative electrode, respectively. Conductive glue 43 is applied by a machine on the positive and negative electrodes of the base 40. Then, the light-emitting diode 30 is turned over to let the transparent substrate be the top layer and the electrodes 35 and 36 face down. After determining the correct polarities of the electrodes 35 and 36, the electrodes 35 and 36 are connected to the conductive glue 43 so as to be fixed on the base and be coupled to the electrodes of the base. Finally, the conductive glue is baked in a suitable temperature during a predetermined time to complete the manufacture of the light-emitting device.

In this embodiment, about half of the light emitted from the p-n junction or the

active layer of the light-emitting device will directly pass through the transparent substrate to the outside, while the other half of the light will direct to the electrode 36. Since the electrode 36 has high efficiency of reflectivity, it can reflect the light through the transparent substrate to the outside, and thus increase the light-emitting efficiency. Further, the electrode 36 provides the current spreading effect to additionally increase the light-emitting efficiency of the light-emitting diode.

In other embodiments of the present invention, the places of the n-type semiconductor layer and the p-type semiconductor layer can be exchanged. In such embodiments, the electrode over the n-type semiconductor layer will be of high reflectivity of light and provides current spreading effect. Said electrode can be of a multi-layer structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag). In embodiments of the present invention, said electrode can be of a multi-layer structure of Ti/Al, Ti/Ag, ITO/Al or ITO/Ag.

The technical features and technical contents of the present invention have been fully disclosed as above. However, various modifications or replacements can be made by people skilled in the art based on the disclosure and teaching of the present invention without departing the spirit of the present invention. Therefore, the scope of the present invention shall not be limited to the above disclosed embodiments and should include said modifications and replacements.

What is claimed is:

1. A flip-chip light-emitting device, comprising
a transparent substrate;
a semiconductor stacked structure arranged over a main surface of said transparent substrate wherein said stacked structure comprises an n-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a p-type GaN-based III-V Group compound semiconductor layer adjacent to said n-type semiconductor layer;
a first electrode being in electrical contact with said n-type semiconductor layer; and
a second electrode being in electrical contact with said p-type semiconductor layer;
wherein said second electrode has good reflectivity of light and covers most of the outer surface of said p-type semiconductor layer.
2. The device of Claim 1 wherein said stacked structure further comprises an active layer placed between said n-type semiconductor layer and said p-type semiconductor layer.
3. The device of Claims 1 or 2 further comprising an insulating layer at least coated on the side surface of the stacked structure, a portion of said first electrode and a portion of said second electrode.
4. The device of Claims 1 or 2 further comprising a base which has a first and a second conductive portions respectively connected to said first and second electrodes.
5. The device of Claim 4 wherein said base can be a conductive lead frame, a glass lead frame, a circuit board or a thin-film circuit.
6. The device of Claims 1 or 2 wherein said second electrode is a multi-layer structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag).

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7. The device of Claims 1 or 2 wherein said second electrode is a multi-layer structure of nickel/gold/titanium/aluminium (Ni/Au/Ti/Al), Indium-Tin Oxide/aluminium (ITO/Al) or Indium-Tin Oxide/silver (ITO/Ag).
 8. A flip-chip light-emitting device, comprising
a transparent substrate;
a semiconductor stacked structure arranged over a main surface of said transparent substrate wherein said stacked structure comprises an p-type GaN-based III-V Group compound semiconductor layer adjacent to said main surface and a n-type GaN-based III-V Group compound semiconductor layer adjacent to said p-type semiconductor layer;
a first electrode being in electrical contact with said n-type semiconductor layer; and
a second electrode being in electrical contact with said p-type semiconductor layer;
wherein said first electrode has good reflectivity of light and covers most of the outer surface of said n-type semiconductor layer.
 9. The device of Claim 8 wherein said stacked structure further comprises an active layer placed between said n-type semiconductor layer and the p-type semiconductor layer.
 10. The device of Claims 8 or 9 further comprising an insulating layer at least coated on the side surface of the stacked structure, a portion of said first electrode and a portion of said second electrode.
 11. The device of Claims 8 or 9 further comprising a base which has a first and a second conductive portions respectively connected to said first and second electrodes.
 12. The device of Claim 11 wherein said base can be a conductive lead frame, a glass lead frame, a circuit board or a thin-film circuit.
 13. The device of Claims 8 or 9 wherein said second electrode is a multi-layer

structure comprising a light-transmitting conductive layer and a layer of aluminium (Al) or silver (Ag).

14. The device of Claims 8 or 9 wherein said second electrode is a multi-layer structure of titanium/aluminium (Ti/Al), titanium/silver (Ti/Ag), Indium-Tin Oxide/aluminium (ITO/Al) or Indium-Tin Oxide/silver (ITO/Ag).

Abstract

The present invention discloses a flip-chip light-emitting device that has improved light-emitting efficiency. The device according to the present invention has an electrode with good reflectivity of light, such that the light directed to the base can be reflected by the electrode to the outside, and thus substantially increase the light-emitting efficiency. In addition, said electrode of the present invention also provide better current spreading effect, and thus further increase the light-emitting efficiency of the light-emitting diode.

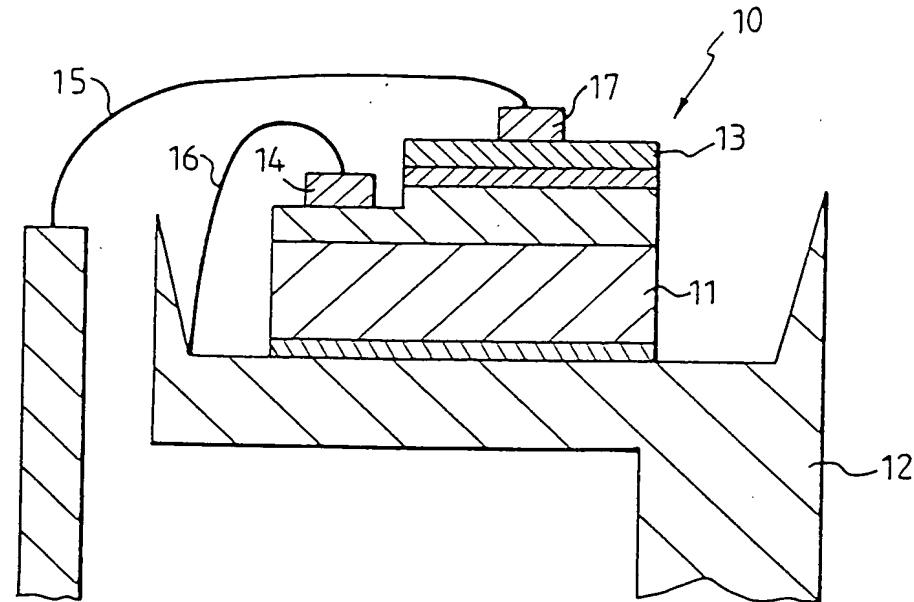


FIG. 1
(Prior Art)

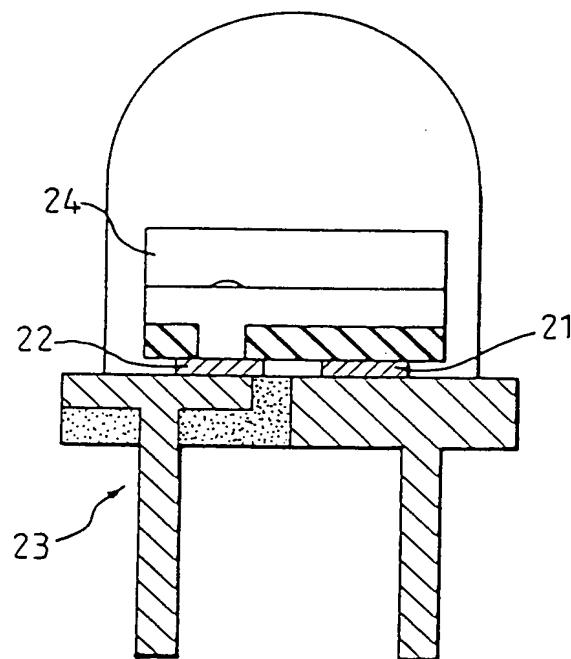


FIG. 2
(Prior Art)

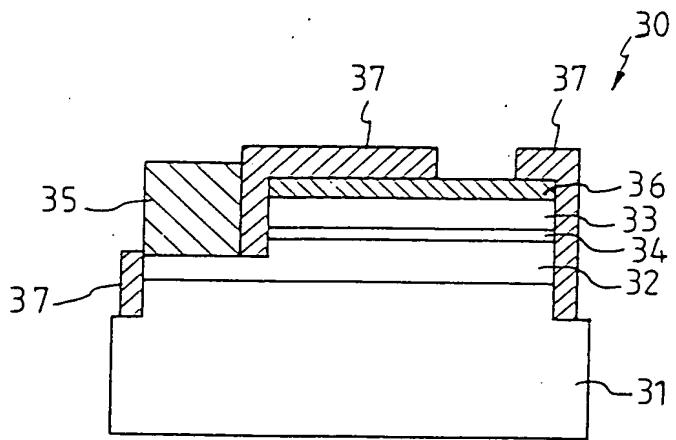


FIG. 3

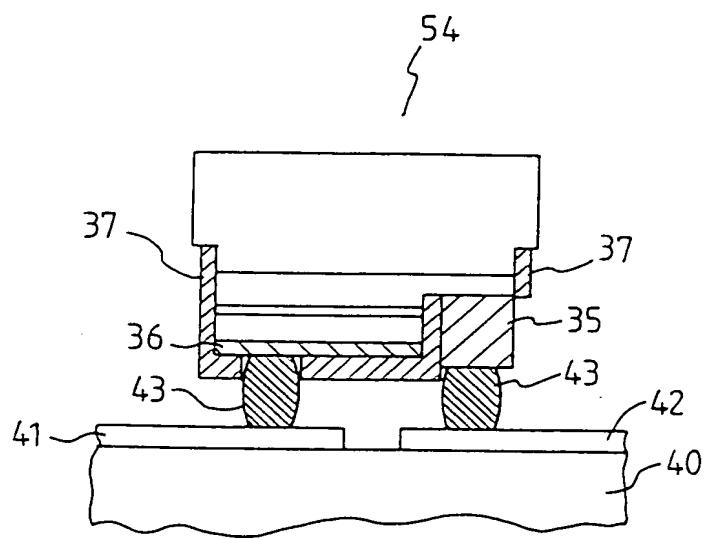


FIG. 4

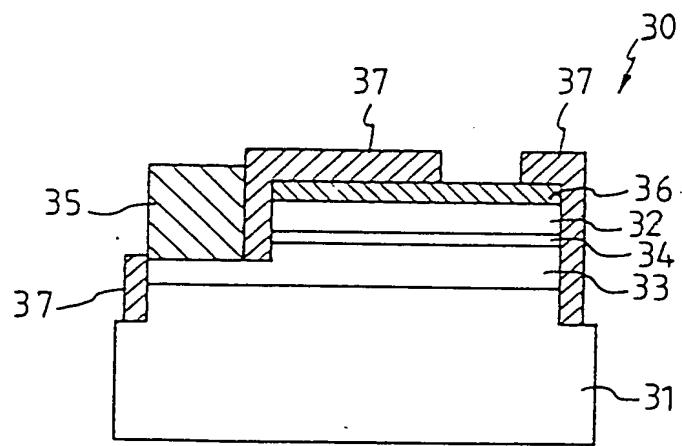


FIG. 5

(22 08 38 30)

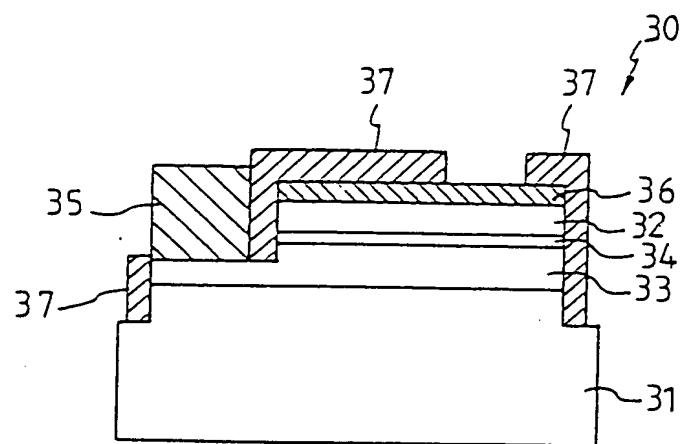


FIG. 5